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RESEARCH PAPER

Carbon Storage on Non-industrial Private Forestland: An Application of the Theory of Planned Behavior

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Abstract Leading scientific experts in the field of climate change suggest that a multifaceted response to global warming should include the use of forest carbon offsets (also known as forest sinks). Emerging emissions reduction legislation in the United States (US) accounts for this recommendation by allowing for carbon offsets derived from domestic forestry projects (e.g. reforestation, afforestation, avoided deforestation). Given that the majority of US forestland is privately owned and non-industrial, the current research employs a behavioral model to measure intentions of private non-industrial forestland owners to participate in carbon sequestration and trading. Results suggest that very few (5.1 %) of these forestland owners are currently involved in carbon sequestration and trading, but half (50.4 %) were at least somewhat interested in exploring opportunities to do so. The Theory of Planned Behavior, acting as the theoretical frame of reference, was extended in the current research to include environmental orientation, innovativeness, perceived risk and tested knowledge, all of which had significant effects on core model constructs: attitude, subjective norms, perceived behavioral control and behavioral intentions. The extended model explained a significant amount of the variance related to behavioral intentions to sequester carbon on private US forestland ($R^2 = .53$).

Keywords Carbon offsets · Forest · Non-industrial private forest owners · Theory of Planned Behavior

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Introduction

Although the effects of human activity on climate change cannot be proven to certainty, there is a general consensus within the scientific community that the earth is warming due to human influence and this warming may be detrimental the earth's inhabitants (IPCC 2007; Oreskes 2004). In response to the concern regarding the detrimental impacts that climate change may have on both nature and humans, a multifaceted response will be required from countries throughout the world. Integral to this approach is utilization of forest carbon sequestration (or *forest sinks*), a mitigation option gaining in recognition and acceptance (IPCC 2007). Forests in the United States (US) hold a significant opportunity for forest carbon sequestration simply due to the area of forestland available for alternative forest management practices (Alig 2003).

In the US, market-based emissions trading frameworks (both voluntary and regulatory) are developing; many of which recognize forest carbon offsets as tradable units. The global financial crisis and partisan politics in both the Congress and Senate have stalled national climate change legislation in the US (e.g. the American Clean Energy and Security Act or the American Power Act); however, demand for these tradable offsets is expected to grow over time (Olander et al. 2009). These stalled pieces of legislation would have allowed for a significant percentage of carbon emissions to be offset by domestic forestry projects. Key to meeting the demands of the carbon market will be the willingness of forestland owners to develop forest carbon offsets on their private lands. Although previous research has analyzed the hierarchy of players involved in the demand-side of the carbon market (e.g. government, firms, NGO's, etc.), there is little extant work regarding supply-side dynamics; namely, private forestland owners and their intentions to develop forest carbon offsets (Bull and Thompson 2011). Ultimately, a clearer understanding of the motivations and barriers experienced by forestland owners will be valuable as programs and policies are developed to attract forestland owners to the carbon marketplace.

The present research applies the Theory of Planned Behavior (TPB) (Ajzen 1991), a model of behavioral intentions, and examines forest management decision-making literature in order to theorize potential antecedents influencing the decision of private forestland owners to develop forest carbon offsets. In addition to the original constructs of the model, this research aims to extend the model to better explain these intentions.

Research Objectives

This survey based research employed a well tested behavioral model to investigate the potential motivations and barriers experienced by US non-industrial private forestland owners as they consider development of forest carbon offsets. In response to knowledge gaps identified in this paper, the following specific research objectives are made:

1. Use the Theory of Planned Behavior (TPB) to measure the effect of *attitude*, *subjective norms* and *perceived behavioral control* on *behavioral intentions* of forestland owners to develop forest carbon offsets (to sequester and trade forest carbon);
2. Extend the TPB to include the effects of the following constructs on intentions of forestland owners to sequester carbon on forestlands:
    a. Environmental orientation
    b. Innovativeness
    c. Perceived risk attached to carbon sequestration and trading
    d. Knowledge of carbon sequestration and trading

Theoretical Background

Reports submitted by the United Nations Intergovernmental Panel on Climate Change (IPCC) and an extensive review of the scientific literature (Oreskes 2004) reveal an overwhelming consensus regarding the presence of global climatic change. The IPCC suggests that a multifaceted, global response is required in order to successfully mitigate the effects of climate change. Included within this multifaceted response is the use of forests as carbon sinks (IPCC 2007). Forests cover approximately 30 % of the Earth's land surface (42 million km^2) capable of sequestering 2.6 billion tons C per year; equivalent to more than 33 % of the anthropocentric carbon emissions resulting from fossil fuel consumption and land use changes (Bonan 2008). In 2005, approximately 14 % of US greenhouse gas emissions were offset by domestic land uses, the vast majority of which occurred due to carbon sequestration by forests (US EPA 2007).

Carbon Markets

Carbon markets in the US can be classified in two categories: regulatory or voluntary. The first two years of the Obama Administration saw the introduction of two pieces of legislation aimed at the creation of a regulatory carbon market. The first piece of legislation, the American Clean Energy and Security Act (ACESA), was introduced in 2009 and passed the US House of Representatives but later stalled in the Senate (OpenCongress 2010). A subsequent bill, the American Power Act, also stalled in 2010. Both pieces of legislation proposed a cap-and-trade emissions reduction framework that allows industrial emitters to buy and trade carbon offsets within a market-based system. Both make reference to the use of domestic forest carbon offsets; however, details have yet to be finalized. Aside from these federally imposed frameworks which do not appear to be gaining sufficient acceptance by federal politicians, other mandatory and voluntary emissions trading frameworks exist. These frameworks vary in scope, size and regulation, including the inclusion/exclusion of forest offsets. For example, the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program, regulates CO_2 emissions, primarily from power plants, in ten Northeast and mid-Atlantic states (RGGI 2009). The Western Climate

Initiative (WCI), a regional regulatory framework under development that recognizes seven partner states and four partner Canadian provinces, plans to include forest offsets from afforestation, reforestation, forest management, forest preservation, and wood products (WCI 2008). Voluntary frameworks in the US, such as the California Climate Action Registry (CCAR) and the now defunct Chicago Climate Exchange (CCX), also accept (or accepted) carbon offsets derived from forestry related activities (CCX 2009; CCAR 2009; VCS 2008).

Forests and Forestland Owners in the United States

Approximately 620 million acres of forested land exists in the US, 63 % of which is privately owned (Butler and Leatherberry 2004). These private forestland holdings are divided into investment owners (or industrial forest owners) and family forest owners (or non-industrial private forest (NIPF) owners). There are approximately 10.3 million NIPF owners in the US accounting for 49 % (304 million acres) of the nation's forestland. It has been estimated that 94 % of the NIPFs are individual owners (rather than groups or organizations) (Birch 1996; Butler and Leatherberry 2004).

Private Forests and Carbon Offsets

Given that NIPF owners hold nearly half of the nation's forestland, private forest owners may become key players in any mitigation strategy involving increased carbon sequestration on US forestland (Alig 2003). Nearly two-thirds of carbon stored in US forests is located on private lands and these lands have capacity for further storage (Birdsey et al. 2000). Motivations of these owners will depend to some degree upon incentive availability (Alig 2003); however, NIPF owners do not always respond to prices and incentives in the same way as forest product companies. The multi-objective nature of NIPF owners often becomes evident as decisions are made for reasons other than financial returns.

Non-timber management goals are often incorporated in overall land management objectives by NIPF owners (e.g. Pattanayak et al. 2002). NIPF owners are increasingly interested in generating income from both timber and non-timber sources (Conway et al. 2002); however, a state-level survey of family forest owners in Massachusetts indicates that economic factors (early withdrawal penalties, contract lengths and accounting requirements) as well as harvest planning and beliefs about climate change may hinder willingness to participate (Markowski-Lindsay et al. 2011). A 2009 survey of similar forest landowners suggested that very few (<7 %) would participate in carbon trading at current prices (Fletcher et al. 2009).

Quite often, forest landowners rely on forest management professionals, such as foresters, during the decision-making process. A survey of professional foresters found that willingness of landowners to participate in carbon offsetting was affected by profitability, compliance difficulties, an immature carbon market, property rights infringements, a moral object to carbon markets, and forester hesitation in recommending participation. An overall lack of foresters' education regarding these markets was also identified as a barrier to participation and the implementation of educational campaigns was suggested (Wade and Moseley 2011).

The Theory of Planned Behavior

To examine and better understand intentions of forest owners to participate in carbon sequestration, the Theory of Planned Behavior (TPB), is applied as the theoretical frame of reference. The TPB (Ajzen 1991) is an extension of the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975). The TRA suggests that a given behavior is dependent upon the intention to perform the behavior, where intentions are dependent upon attitudes towards the behavior and subjective norms (or social pressures). The TPB extended the TRA by including a *perceived behavioral control* construct which also acts as an antecedent to behavioral intentions.

The TPB has been applied in a variety of forestry and natural resource based studies encompassing forest management, forest regeneration, and willingness-to-pay research. Typically, results from these studies have found that the TPB constructs relate as hypothesized in Ajzen's (1991) original model (Pouta and Rekola 2001; Karppinen 2005).

Theoretical Frame of Reference

The TPB acts as the theoretical frame of reference for this research. The literature suggests that the addition of four constructs (environmental orientation, innovativeness, perceived risk, and knowledge) may better explain behavioral intentions by forestland owners to develop forest carbon offsets than the original TPB model.

Constructs of the Theory of Planned Behavior

Behavioral intentions indicate one's willingness and preparedness to perform a given behavior and are assumed to be a direct antecedent of actual behavior. It is based on attitude towards the behavior, subjective norms, and perceived behavioral control, the influence of each varying based on specific behavior and population of interest.

Attitudes

An antecedent of behavioral intentions, *attitude* toward a behavior indicates one's evaluation (positive or negative) of one's self-performance of the given behavior. Attitude (A), as expressed in the equation below, is determined by a series of salient beliefs (b_i) regarding the behavior, each combined multiplicatively with a subjective evaluation (e_i) of the belief's attribute (n denotes the total number of salient beliefs).

$$A = \sum_{i=1}^{n} (b_i e_i)$$

H1 Attitude will positively influence behavioral intentions to participate in forest carbon sequestration and trading.

Subjective Norms

An individual's *subjective norm* refers to his/her perceived social normative pressures which may influence (positively or negatively) the intention to perform a given behavior. As shown in the equation below, Subjective norms (SN) are developed from normative beliefs (nb_i) regarding the behavior, each combined multiplicatively with a measure of the motivation to comply (mc_i) for each normative belief (*n* denotes the total number of normative beliefs).

$$SN = \sum_{i=1}^{n} (nb_i mc_i)$$

Normative beliefs derived from forest management consultation professionals (Royer 1985) and forestland owner associations (Straka and Doolittle 1988) have been found to be influential in forestland owner decision making. The impact of one forestland owner's decision on the structure, diversity, or boundary of forestland used by another owner can be considered a type of economic externality in the realm of private forest management (Amacher et al. 2002).

Although studies recognize the importance of examining the effects of adjacent landowner behavior on a given forest landowner's behavior (e.g. Amacher et al. 2003), there is very little empirical evidence available to support or refute a significant effect of adjacent landowners on forest management behavior. While evidence of willingness to cooperate with adjacent landowners exists (Jacobson 2002a), the literature lacks behavioral modeling which may expose potential antecedents to behavioral intentions to participate in a given management activity. This is especially relevant to carbon sequestration and trading as there may be benefits to selling aggregate carbon credits. Jacobson (2002a) adds that interest in joint management of forestland decreases if landowners do not understand the benefits of coordination with other landowners.

H2 Increasing subjective norms (i.e. increasing normative pressures) will positively influence behavioral intentions to participate in forest carbon sequestration and trading.

Perceived Behavioral Control

The single construct that differentiates the TPB from the TRA, *perceived behavioral control,* refers to the perceived ease or difficulty one experiences regarding the performance of a particular behavior. As illustrated in the equation below, perceived behavioral control (PBC) is created based on control beliefs (cb_i) which express one's beliefs about the presence of factors that may assist or hinder performance of a behavior. These beliefs are combined multiplicatively with the perceived power (pp_i) of the control belief under consideration (*n* denotes the total number of control beliefs).

$$PBC = \sum_{i=1}^{n} (cb_i pp_i)$$

H3 Increasing perceived behavioral control will positively influence behavioral intentions to participate in forest carbon sequestration and trading.

Logical Extensions of the Theory of Planned Behavior

Innovativeness

Innovativeness has been defined as "the degree to which an individual is relatively more ready to adopt an innovation than other members of his system" (Rogers and Shoemaker 1971). The diffusion of innovations approach, developed by Straka and Doolittle (1988), was modified from the agricultural technology adoption literature with an aim to examine how information regarding products and processes is communicated and whether individuals responded to it through changes in behavior. Their results suggest that more innovative forestland owners tended to be more likely to participate in reforestation and forest rehabilitation activities.

The TPB is suitable for the inclusion of an innovativeness construct given that the TPB utilizes the effect of social influence (subjective norms), a variable traditionally associated with the diffusion of innovations (Mahajan et al. 1990; Rogers 1995). These studies outline the importance of an innovative individual/company's ability to act in response to the needs and wants of important members of the value chain. Examining the acceptance of new consumer aiding technologies, Crespo and del Bosque (2008) found innovativeness to have a significant positive effect on both attitude and behavioral intention.

H4 Increasing innovativeness will positively influence attitudes, subjective norms and intentions regarding forest carbon sequestration and trading.

Perceived Risk

Perceived risk can be described as a cognitive assessment of a threat or hazard (Schmiege et al. 2009). Studies that have examined the role of risk perception related to various forest management decisions suggest that perceived risk is an important predictor of behavioral intentions to undertake various management practices (e.g. Conway et al. 2002). Hardner et al. (2000) concluded that perceived risk plays an important role in the willingness of landowners to participate in any sort of carbon sequestration project. Both direct and indirect effects of perceived risk on intentions through attitudes are well-supported (e.g. Lobb et al. 2007). Schmiege et al. (2009) also found perceived risk to negatively influence self-efficacy (i.e. perceived behavioral control).

H5 Increasing perceived risk perceived by forestland owners will negatively influence attitudes, perceived behavioral control, and intentions related to carbon sequestration and trading.

Environmental Orientation

A pro-environmental orientation tends to positively influence one's attitude towards pro-environmental activities (Dunlap et al. 2000). A scale commonly used to

measure pro-environmental orientation is the anthropocentric/biocentric value orientation scale which suggests that value orientations related to natural resources range on a scale from anthropocentric (human-centered) to biocentric (nature-centered) (Thompson and Barton 1994).

Previous studies (e.g. Vaske and Donnelly 2000) have employed four questionnaire items to measure biocentric basic beliefs and five items to measure anthropocentric basic beliefs. For example, a biocentric statement might be: *Forests have value, whether people are present or not*. An anthropocentric statement may be: *The value of forests exists only in the human mind*. Vaske and Donnelly (2000) reported that the biocentric/anthropocentric value orientations positively influenced preservation-based attitudes; a relationship that is supported by results from similar studies involving environmental values (e.g. Cary and Wilkinson 2008).

The present research classifies carbon sequestration as a pro-environmental activity; however, this classification can become a point of debate. Given the substantial support for forest carbon sequestration as a climate change mitigation tool (IPCC 2007), the current classification is appropriate.

H6 Increasing biocentric environmental orientation of forestland owners will positively influence attitudes towards forest carbon sequestration and trading.

Knowledge of Forest Carbon Offsets

Empirical studies involving forestland owners reveal an overall lack of familiarity and knowledge related to alternative forest management practices (e.g. ecosystem management), despite showing significant interest in participation (Jacobson 2002b). There is some evidence to suggest that knowledge of the environment (in general) as well as specific knowledge of a particular pro-environmental behavior act as antecedents to both attitudes and intentions towards a particular behavior (Hines et al. 1987). Similarly, knowledge gained through past behavior has been found to positively influence both 'everyday' tasks and pro-environmental behavioral intentions (Schmiege et al. 2009; Kilgore et al. 2008).

Knowledge has also been found to positively influence subjective norms and self-efficacy (perceived behavioral control) related to behavioral intentions towards behaviors (e.g. environmental management, reforestation, harvesting) (e.g. Royer 1985). Particularly relevant to the TPB, the literature suggests that knowledge of an innovation directly influences one's perceived behavioral control regarding intentions to utilize the innovation (Lehman et al. 2002). Huang and Chuang (2007) add that knowledge based on past experience negatively influences perceived risk related to a given behavior.

H7 Increasing knowledge of forest carbon offset development will positively influence attitudes, perceived behavioral control and intentions regarding forest carbon sequestration and trading.

H8 Increasing knowledge of forest carbon offset development will reduce perceived risk related to forest carbon sequestration and trading.

Operationalization of Model Constructs

Individual constructs within the original model are measured using scales adapted from previous applications of the model. Scales generated in forest management studies are used wherever possible. Table 1 shows the questionnaire items used to measure each construct and the corresponding literature from which items were adapted. Multiple measures of attitude, subjective norms and perceived behavioral control are used and grouped based on reliability analyses where appropriate. Given that many of these constructs are scale-items (e.g. 1–5, neutral = 3), in the interest of clarity, the results section will aggregate responses into smaller subgroups (e.g. <3 = disagree, 3 = neutral, >3 = agree).

Behavioral intentions (*BI*) to participate in carbon sequestration and trading were measured based on four items regarding plans to use forestland for carbon sequestration and trading in the future. Answers are based on agreement with statements and provided on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Attitudes (*A*) regarding carbon sequestration were measured in two ways. First, an agreement scale measuring self-appraised disposition or overall attitude regarding the behavior within the next five years was applied using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Second, attitude (A) was measured based on five salient belief statements (b) and belief outcome evaluations (e). Each belief statement was measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). For each belief, respondents were asked to indicate belief outcome evaluations which were also measured on a 5-point scale ranging from 1 (not at all important) to 5 (very important). Multiple measures are used to increase the reliability of each construct.

Subjective Norms (*SN*) were first measured by two scale items regarding the opinion of important people in a respondent's life, ranging from 1 (strongly disagree) to 5 (strongly agree). Second, subjective norms (SN) were measured based on five normative beliefs (nb) and corresponding measures of motivation to comply (mc). Each normative belief was measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). For each normative belief, respondents were asked to indicate their motivation to comply (the importance of these normative beliefs) on a 5-point scale ranging from 1 (not at all important) to 5 (very important).

Perceived behavioral control (*PBC*) was first measured by two scale items regarding the plausibility of sequestering carbon on forestland. These 5-point scales range from 1 (strongly disagree) to 5 (strongly agree). Perceived behavioral control (PBC) was also measured based on two control beliefs (cb) and perceived power of the control factor (pp). Each control belief was measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). For each control belief, perceived power of the control factor was measured based on a 5-point scale ranging from 1 (not at all important) to 5 (very important).

Generation of Extended Model Constructs

Innovativeness (*Innov*) in forestland owners was measured with four scale items which addresses the adoption of forest management practices. This series of items

Table 1 Theory of Planned Behavior constructs and questionnaire items

Item	Adapted from
Behavioral intention (BI)	
BI_1 I plan to use (or continue to use) at least part of my forestland for forest carbon sequestration	Harland et al. (1999)
BI_2 I intent to participate in the forest carbon trading market	
BI_3 I plan to take (or have already taken) the necessary steps to use my forestland for carbon sequestration	Karppinen (2005)
BI_4 I am interested in exploring carbon sequestration opportunities on my forestland	
Attitude (A)	
A_1 I feel positively about the possibility of participating in carbon sequestration and trading on my forestland	Karppinen (2005)
Belief strength (b) × Belief outcome's evaluation (e)	
b_1 In the long term, carbon sequestration and trading can increase the revenue generated from my forestland	Francis et al. (2004)
b_2 Participating in forest carbon sequestration and trading helps minimize climate change	
b_3 Carbon sequestration would improve other forest values on my land (e.g. scenery, naturalness, tree quality etc.)	
b_4 In the short term, carbon sequestration and trading will provide increased revenue from my forestland	
b_5 The cost of managing my forests for carbon sequestration is too high	Pouta and Rekola (2001)
Subjective norm (SN)	
SN_1 Most people important in my life would approve of my participation in forest carbon sequestration and trading	Karppinen (2005)
SN_2 Most people important in my life think that I should participate in forest carbon sequestration and trading	
Normative beliefs (nb) × Measure of the motivation to comply (mc)	
nb_1 Family members believe I should participate in forest carbon sequestration and trading	Karppinen (2005), Francis et al. (2004)
nb_2 Forestry professionals and/or forest management associations believe I should participate in forest carbon sequestration and trading	
nb_3 Neighbors (adjacent landowners) believe I should participate in forest carbon sequestration and trading	
nb_4 Friends believe I should participate in forest carbon sequestration and trading	
nb_5 Most forestland owners I know are involved in (or considering) carbon sequestration on their land	
Perceived behavioral control (PBC)	
PBC_1 It is possible to participate in carbon sequestration and trading on my forestland	Karppinen (2005)
PBC_2 I think I can manage my forestland for carbon sequestration values	Pouta and Rekola (2001)
Control beliefs (cb) × perceived power of the control factor (pp)	
cb_1 I have the necessary financial resources to manage my forestland for carbon sequestration	Karppinen (2005), Francis et al. (2004)
cb_2 The characteristics of my forestland are suitable for forest carbon sequestration	

aimed to measure the adoption of management techniques/strategies and the importance of external innovations. Each of the four items was measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree) (see Table 2 for a complete list of added constructs and corresponding variables).

Environmental orientation (*EO*) was measured using four biocentric (bio) belief statements and four anthropocentric (anthro) belief statements to which respondents were to respond using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Anthropocentric responses were reverse coded post-survey. The mean of responses to each belief statement represented overall environmental orientation (higher scores indicated a more biocentric orientation).

Perceived risk (*PR*) was measured using hazard scales adapted from measures used in both forestry and non-forestry related studies. Responses to the existence of four distinct hazards (h) related to forest carbon sequestration were measured using 5-point scales ranging from 1 (strongly disagree) to 5 (strongly agree). For each hazard, corresponding hazard importance scores (his) measured the importance respondents place on each hazard and were measured on 5-point scales ranging from 1 (not at all important) to 5 (very important). The mean of $h \times his$ for each hazard resulted in an overall perceived risk (PR) score.

Knowledge (*Kn*) of the behavior was first measured by a self-appraised knowledge scale (Skn) adapted from the literature. Respondents were asked to indicate their agreement with two statements related to their knowledge and understanding of carbon sequestration and trading based on two 5-point scales ranging from 1 (strongly disagree) to 5 (strongly agree). In addition, knowledge was assessed by a series of five true/false questions related to carbon sequestration and trading (MK). Respondents were asked to indicate their perception of the statement using a 5-point scale ranging from 1 (quite confident this is false) to 5 (quite confident this is true). Correct responses (cr) were assigned a value of '1' and incorrect (or neutral responses) were assigned a value of '0'. Assigned values were summed for each respondent to create an overall knowledge score.

Demographics and *land characteristics* data was collected in addition to model constructs in order to provide a respondent profile and generalized characteristics of forestland belonging to the target population. At the end of the mail questionnaire, respondents were given the opportunity to provide comments regarding carbon sequestration and trading on forestland.

Methods

Sampling

Target Population

This research evaluated the intentions of US NIPF owners to participate in the development of forest carbon offsets. Consistent with previous landowner surveys (e.g. Butler 2008), forestland owners with a minimum of ten acres of land were included in the target population.

Table 2 Extended model constructs and questionnaire items

Item	Adapted from
Innovativeness (Innov)	
$Innov_1$ I tend to use new forest management techniques before my fellow forestland owners	Deshpande et al. (1993), Wang and Ahmed (2004)
$Innov_2$ I am able to implement new management strategies used by other forestland owners	Jerez-Gomez et al. (2005)
$Innov_3$ I consider ideas about management practices from external sources to be critical to the sound management of my forestland	Jerez-Gomez et al. (2005)
$Innov_4$ I actively seek new forest management practices	Hurley and Hult (1998), Jerez-Gomez et al. (2005)
Environmental orientation (EO)	
Biocentric beliefs (bio)	Vaske and Donnelly (2000)
bio_1 Forests have value, whether people are present or not	
bio_2 Forests have as much right to exist as people	
bio_3 Nature has as much right to exist as people	
bio_4 Wildlife, plants, and people have equal rights to live and develop	
Anthropocentric beliefs (anth)	Vaske and Donnelly (2000)
$anth_1$ Nature's primary value is to provide products useful to people	
$anth_2$ The primary value of forests is to provide timber, grazing land, and minerals for people who depend on them for their way of life	
$anth_3$ The primary value of forests is to generate money and economic self-reliance for communities	
$anth_4$ Forests are valuable only if they produce jobs and income for people	
Perceived risk (PR) (hazard (h) × hazard importance score (his))	
h_1 I may notice a decrease in revenue from my forestland if I participate in carbon sequestration and trading	Dowling and Staelin (1994)
h_2 The price of forest carbon is unpredictable	Blennow and Sallnas (2002)
h_3 Sequestering carbon may decrease the dollar value of my land	
h_4 Sequestering and trading carbon may prevent me from managing my forestland for other values that are important to me	
Knowledge of behavior (Kn)	
Self-appraised carbon sequestration knowledge (SKn)	
My knowledge of forest carbon sequestration and trading is quite good	Uliczka et al. (2004)
My understanding of the steps required to participate in forest carbon sequestration and trading is quite good	
Measured knowledge (MK) [correct responses (cr)]	
cr_1 Any forestland owner can enter the carbon trading market	McFarlane and Boxall (2000)
cr_2 The largest voluntary carbon market in the US is the Chicago Climate Exchange. (*note: *the CCX was functioning at time of survey*)	

Table 2 continued

Item	Adapted from
cr_3 Forest carbon is traded in units called 'Forbons'	
cr_4 Only softwood tree species are eligible for carbon credits	
cr_5 Forest carbon sequestration and trading can be done without a written management plan	

Sampling Frame

A mailing list with addresses and telephone numbers was purchased from Martin Worldwide™, a mailing list provider. After consulting with experts in the field of national forestland owner surveys, mailing list providers were identified as the preferable source of a reliable sampling frame within the budgetary constraints of the project. Martin Worldwide identified forestland owners based on land-use classifications assigned by the county assessor for tax purposes.

Sampling Procedure

Consistent with national surveys of forestland owners by the USDA Forest Service, stratified random sampling was employed to ensure adequate sample sizes in each of the three distinct US forest regions (North, South and West) (Butler and Leatherberry 2004; Butler 2008) (Fig. 1).

Based on 5 % error and a 95 % confidence interval, a sample size of 384 is required. Questionnaires were mailed to 2,949 forestland owners (North: n = 984; South: n = 982; West: n = 983).

Data Collection

Questionnaire Development and Survey Approach

After initial reviews by experts in the field, the survey questionnaire was pretested on six forestland owners (>10 acres) known to the researchers. Comments and critiques were addressed in order to improve the clarity and relevance of the questionnaire. Subsequently, a pilot survey was conducted using 100 potential respondents randomly selected from the mailing list. The pilot survey provided an indication of response rate as well as feedback related to questionnaire clarity and relevance. There was initial concern that a hypothetical bias would occur in which respondents would be more likely to choose a hypothetical situation over an actual situation (e.g. Cummings et al. 1997); however, given that the purpose of this study was to determine the behavioral antecedents to participation (rather than to provide quantification of interested participants) the effect of such a hypothetical bias would be equal for all surveyed landowners.

The survey procedure, carried out in April 2010, followed mail survey procedures outlined by Dillman (2007) that are thought to improve survey response rates. Approximately three weeks after the first mailing of the questionnaire, a

Fig. 1 Distinct forest regions of the United States (USDA 2001)

follow-up questionnaire was mailed. Each questionnaire was accompanied by an individually signed letter outlining the study.

To examine potential non-response bias, respondents were compared to those that did not return a questionnaire. A random sample of 50 non-respondents were telephoned and asked five questions from the mail survey. Non-respondents were called in a random order until 50 non-respondents answered the telephone call. Questions were chosen that could be easily communicated via telephone and did not require extensive explanation. Each variable was continuous, allowing for comparison between samples using a t test. Insignificant results ($p > .05$) indicate that respondents and non-respondents were statistically similar. Non-response bias test questions and t test results were as follows: "How many acres of land do you own?" (t value = .56; $p = .57$; $r_{pb} = .02$), "I actively seek new forest management practices" (t value = .95; $p = .34$; $r_{pb} = .04$), "Forests have as much right to exist as people" (t value = 1.89; $p = .16$; $r_{pb} = .09$), "Nature's primary value is to provide products useful to people" (t value = .56; $p = .58$; $r_{pb} = .02$), "How long have you owned your land?" (t value = −1.48; $p = .14$; $r_{pb} = -.06$).

The sample was also compared based on demographic characteristics listed in the National Woodland Owner Survey conducted semi-annually by the US Department of Agriculture Forest Service. No significant differences were found based on income, age and education.

Statistical Analyses

Prior to statistical analyses, data was checked for missing or invalid responses, as well as normality (e.g. skewness or kurtosis). All statistical analyses were performed using SPSS 16 statistical software. Reliability analysis was performed to ensure that variables were measuring the same latent construct. OLS regression and path analysis were used to test the significance of relationships between model constructs (e.g. behavioral intentions and attitudes). Regression and path analysis has been found to be a suitable form of analysis in similar studies examining hypothesized cause-effect relationships (e.g. Barr 2007). Insignificant relationships were removed

and regressions rerun. A path diagram was plotted with standardized β values for each relationship and R^2 values describing the explained variance for each criterion.

Additional regression analyses were used to determine mediation by model constructs. Following Baron and Kenny (1986), mediation is detected by comparing standardized coefficients and significance between direct effects (predictor to criterion) before and after the addition of a potential mediator. A reduced significant direct effect β with the addition of a mediator indicates partial mediation. A near-zero or insignificant β indicates full mediation.

Construct Reliability

To test for measurement invariance, SPSS 16 statistical software was used to perform reliability analyses on multiple variables used to measure single constructs. Cronbach's alpha values ≥.65 indicated acceptable reliability of construct measures (Nunnelly 1970). Provided that Cronbach's alpha *if item deleted* values were less than overall Cronbach's alpha values, and corrected item-total correlations were ≥.40, reliability was acceptable. Analyses showed reliability within each of the main constructs of the TPB. See Table 3 for reliability analyses related to each construct.

Constructs developed as extensions to the TPB were also tested for construct reliability. Innovativeness and perceived risk were found to be reliable; however, the environmental orientation (anthropocentric-biocentric continuum) contained two variables that increased the overall Cronbach's alpha if removed. See Table 4 for a full list of reliabilities for constructs used in the extended model.

Results

Response Information

After accounting for bad addresses, respondents outside of the target population, and the deceased, the adjusted sample size was 2,742. A total of 435 completed questionnaires were returned, resulting in an adjusted response rate of 15.9 %, which is consistent with other studies in the field of ecosystem valuation (e.g. Costanza et al. 1989).

Respondent Profile

The mean acreage size and length of ownership was 267.6 acres and 25.6 years, respectively. Respondents reported a mean age of 60.1 years (Table 5).

The majority of respondents held forestland in the West and the Northeast (38 and 37 %, respectively), were predominantly male (76 %), Caucasian (92 %) and non-retired (56 %), and had completed at least a four-year college degree (4 year degree: 30 %; advanced degree: 29 %). Income was relatively evenly distributed across income classes. Household income of $50,000–74,999 was reported most frequently (21 %) (Table 6). Approximately 74 % of the respondents lived in the same state as their forestland holdings and 45 % had a primary residence on their forestland.

Table 3 Construct reliability—core constructs within the Theory of Planned Behavior

Concepts and variables	Mean	Std dev.	Item total correlation	Cronbach alpha if item deleted	Cronbach alpha
Behavioral intention (BI)					.86
BI_1	2.92	.95	.73	.81	
BI_2	2.70	.89	.77	.79	
BI_3	2.60	.95	.69	.82	
BI_4	3.42	1.17	.65	.85	
Attitudes (A)					.82
A_1	3.15	1.13	.66	.82	
$b_1 \times e_1$	11.49	5.50	.76	.75	
$b_2 \times e_2$	11.24	6.50	.61	.80	
$b_3 \times e_3$	12.18	5.51	.69	.77	
$b_4 \times e_4$	10.85	4.92	.64	.78	
$b_5 \times e_5$[a]	11.09	3.62	.51	.81	
Subjective norms (SN)					.84
SN_1	3.25	.96	.48	.84	
SN_2	2.80	.86	.64	.84	
$nb_1 \times mc_1$	8.73	4.58	.63	.82	
$nb_2 \times mc_2$	9.41	4.05	.67	.81	
$nb_3 \times mc_3$	7.09	3.69	.73	.80	
$nb_4 \times mc_4$	7.84	3.92	.78	.79	
$nb_5 \times mc_5$	6.67	3.61	.69	.81	
Perceived behavioral control (PBC)					.67
PBC_1	3.18	.89	.62	.67	
PBC_2	3.23	.89	.64	.66	
$cb_1 \times pp_1$	11.72	4.73	.64	.45	
$cb_2 \times pp_2$	12.51	5.16	.69	.41	

[a] Reverse-coded; see Table 1 for variable descriptions

Components of the Theory of Planned Behavior

The means and standard deviations of the main components in the TPB are shown in Table 3. The following observations represent forestland owners that agreed (either strongly or moderately) with questionnaire items related to forest carbon offsets. Approximately 18 % of respondents planned to manage their forestland for carbon offsets ($BI_1 = 2.92$) and 37 % reported an overall positive attitude towards the idea of managing their forestland for carbon ($A_1 = 3.15$). However, over half of the respondents (50 %) were supportive of exploring carbon sequestration opportunities on their land ($BI_4 = 3.42$). Measures of subjective norms suggested that 36 % felt important people in their life would approve of the decision to manage for carbon ($SN_1 = 3.25$), but only 9 % suggested that these important people would encouraged them to do so ($SN_2 = 2.80$). With regards to perceived behavioral

Table 4 Construct reliability—innovativeness, environmental orientation, perceived risk

Concepts and variables	Mean	Std dev.	Item total correlation	Cronbach alpha if item deleted	Cronbach alpha
Innovativeness (Innov)					.79
$Innov_1$	3.02	.9	.63	.73	
$Innov_2$	3.23	.91	.63	.72	
$Innov_3$	3.28	1.06	.54	.77	
$Innov_4$	3.22	1.04	.62	.73	
Environmental orientation (EO)					
Biocentric basic beliefs (bio)					.86
bio_1	4.47	.82	.34	.93[a]	
bio_2	3.67	1.35	.87	.75	
bio_3	3.82	1.32	.87	.75	
bio_4	3.51	1.37	.80	.78	
Anthropocentric basic beliefs (anth)					.86
$anth_1$	3.18	1.30	.76	.81	
$anth_2$	3.23	1.23	.79	.79	
$anth_3$	2.80	1.18	.77	.80	
$anth_4$	2.06	1.06	.54	.89[a]	
Percieved risk (PR)					.83
$h_1 \times his_1$	10.25	4.01	.71	.76	
$h_2 \times his_2$	11.15	4.40	.60	.81	
$h_3 \times his_3$	11.75	4.25	.68	.78	
$h_4 \times his_4$	12.18	4.41	.64	.79	

[a] Removed due to Cronbach alpha if item deleted > overall Cronbach alpha

See Table 2 for a description of each variable

Table 5 Respondent descriptors: acres of forestland, years of ownership, and age

Descriptor	Mean	Std. dev.	Min	Max	n
Acres of land	267.6	1,186.8	10.0	15,000	429
Years owned	25.6	18.0	1	85	425
Age	60.1	12.6	24	92	409

* One outlier was identified and removed (845,000 acres)

control, 30 % of the respondents believed it was possible to participate in carbon sequestration and trading on their forestland ($PBC_1 = 3.18$).

Components of the Extended Model

The means and standard deviations of the extended components of the model used in this research can be found in Table 4. Results show that 22 % of respondents

Table 6 Demographic profile of respondents

Descriptor	n	%	Descriptor	n	%
Region			**Education**		
West	162	37.6	Less than high school diploma	6	1.4
Northeast	161	37.4	High school diploma	107	25.4
South	105	24.5	2-year assoc. degree/trade school	64	15.2
	428		4-year college degree	124	29.5
Gender			Advanced degree beyond 4-year degree	120	28.5
Male	315	76.1		421	
Female	99	23.9	**Household income**		
	414		Less than $15,000	15	4.0
Retired			$15,000–34,999	62	16.7
No	232	55.5	$35,000–49,999	52	14.0
Yes	139	32.3	$50,000–74,999	78	21.0
Semi-retired	47	10.9	$75,000–99,999	59	15.9
	418		$100,000–129,999	45	12.1
Race			$130,000–149,999	17	4.6
American Indian	6	1.5	$150,000–199,999	22	5.9
Black/Afr. Amer	13	3.2	$200,000 or more	22	5.9
Spanish/Latino	2	.5		372	
Caucasian	376	92.4			
Other	10	2.5			
	407				

claimed to use new forest management techniques before their fellow forestland owners, 38 % are able to implement new management strategies used by other forestland owners, 40 % considered ideas about management practices from external sources to be critical to the sound management of their forestland, and 38 % actively sought new forest management practices. Over half of the respondents (58 %) reported more biocentric than anthropocentric views regarding environmental orientation.

The majority of respondents did not perceive risks relevant to managing forestland for carbon offsets. Very few respondents agreed with the presence of risks such as reduction in revenue from forestland (8 %), the unpredictable price of carbon (24 %), decreased value of land (11 %) or prevention of managing forestland for other values (20 %).

Overall, respondent knowledge, based on answers to true/false questions, was quite low. Nearly half of respondents (49 %) answered each true/false question incorrectly, while 14 % were able to answer one question correctly, 16 % were able to answer two questions correctly, 16 % were able to answer three questions correctly, and 6 % were able to answer four questions correctly. None of the respondents were able to correctly answer all five true/false questions.

Relationships Within the Extended Model

As shown in Table 7, TPB constructs correlated as theorized by Ajzen (1991). Attitudes, subjective norms and perceived behavioral control each demostrated large positive effects on behavioral intentions to manage forestland for carbon offsets (Pearson's correlation = .65, .50, and .59, respectively).

Regression analyses were performed consistent with hypothesized relationships within the extended TPB (Fig. 2). Insignificant predictors were removed and the regressions rerun as necessary (Fig. 3). All direct effects on behavioral intentions were found to be significant with the exception of perceived risk ($\beta = -.01$; $p = .74$). Hypothesized direct effects on attitudes and subjective norms were also found to be significant. The effect of perceived risk on perceived behavioral control was insignificant ($\beta = -.01$; $p = .81$) as was the effect of knowledge on perceived risk ($\beta = .03$; $p = .52$) (fail to support H8).

Direct effects explained a substantial amount of variance within the criterion (behavioral intentions) ($R^2 = .53$). Perceived behavioral control was found to have the largest standardized coefficient ($\beta = .32$), followed by attitudes ($\beta = .29$) and subjective norms ($\beta = .14$) (in support of H1, H2 and H3). Innovativeness also had a significant coefficient of $\beta = .20$ (in support of H4). Knowledge had a significant negative effect on behavioral intentions ($\beta = -.13$) (partial support for H7). Hypothesized predictors of attitudes resulted in a coefficient of determination of $R^2 = .18$. More innovative forestland owners tended to have a more positive attitude regarding carbon sequestration ($\beta = .30$) (in support of H4). Similar

Table 7 Correlations between constructs explaining the intention to participate in carbon sequestration and trading (BI)

	BI	A	SN	PBC	Innov	EO	Perc. risk
BI	1.00						
A	.65**	1.00					
	n = 384						
SN	.50**	.60**	1.00				
	380	380					
PBC	.59**	.69**	.40**	1.00			
	390	382	380				
Innov	.40**	.32**	.21**	.29**	1.00		
	396	379	375	385			
EO	.17**	.28**	.23**	.13**	.05	1.00	
	391	377	373	382	391		
Perc. risk	−.11*	−.13*	−.12*	−.02	.02	−.15**	1.00
	387	381	379	385	381	380	
Knowledge	−.03	.13**	−.12*	.17**	.11*	−.002	.03
	395	376	373	386	388	380	377

Pearson's correlation coefficients and number of observations

** Significant at $p < .01$; * Significant at $p < .05$

positive relationships with attitudes were found for environmental orientation ($\beta = .25$) (in support of H6) and knowledge ($\beta = .11$) (partial support for H7). As hypothesized, perceived risk negatively influenced attitudes in the extended model ($\beta = -.11$) (partial support for H5).

Coefficients of determination were relatively low for subjective norms and perceived behavioral control given that only one predictor was found to be significant for each. Innovativeness positively influenced subjective norms ($\beta = .21$; $R^2 = .04$). Similarly, knowledge positively influenced perceived behavioral control ($\beta = .17$; $R^2 = .03$).

Attitude was found to fully mediate the relationship between perceived risk and behavioral intentions. With other constructs removed, the direct effect of perceived risk on intentions ($\beta = -.11$; $p = .03$) decreased and became insignificant ($\beta = .01$; $p = .77$) with the addition of attitude to the model. Attitude partially mediated the relationship between innovativeness and intentions (direct effect: $\beta = .40$; $p < .001$, with attitude: $\beta = .22$; $p < .001$). Attitude was found to fully mediate the relationship between knowledge and behavioral intentions (direct effect: $\beta = -.03$; $p = .59$, with attitude: $\beta = -.11$; $p = .05$). The relationship between innovativeness and intentions was also partially mediated by subjective norms (direct effect: $\beta = .40$; $p < .001$, with subjective norms: $\beta = .31$; $p < .001$). Perceived behavioral control fully mediated the relationship between knowledge

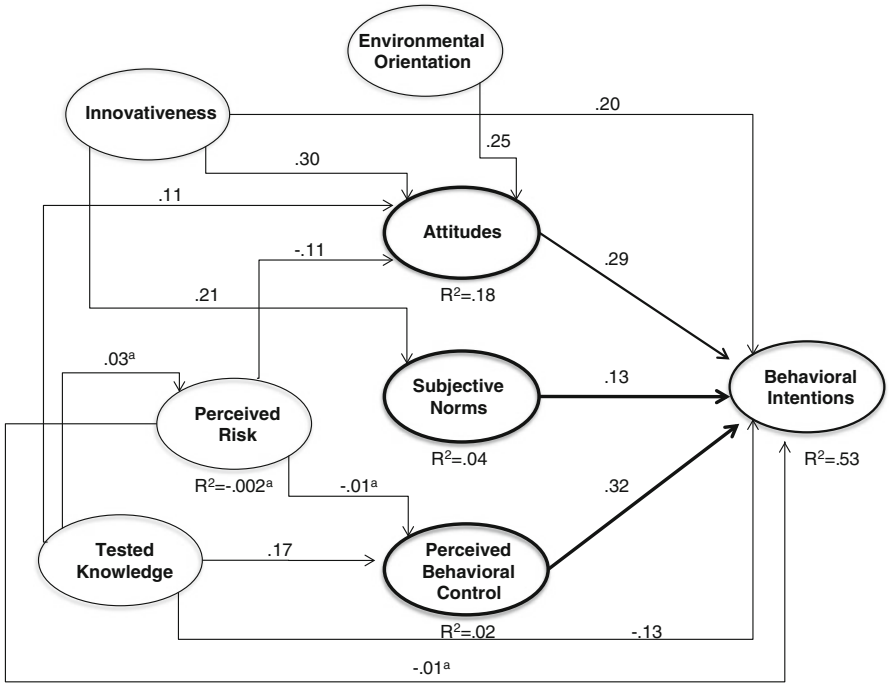

Fig. 2 Extended Theory of Planned Behavior model (with significant and insignificant relationships)

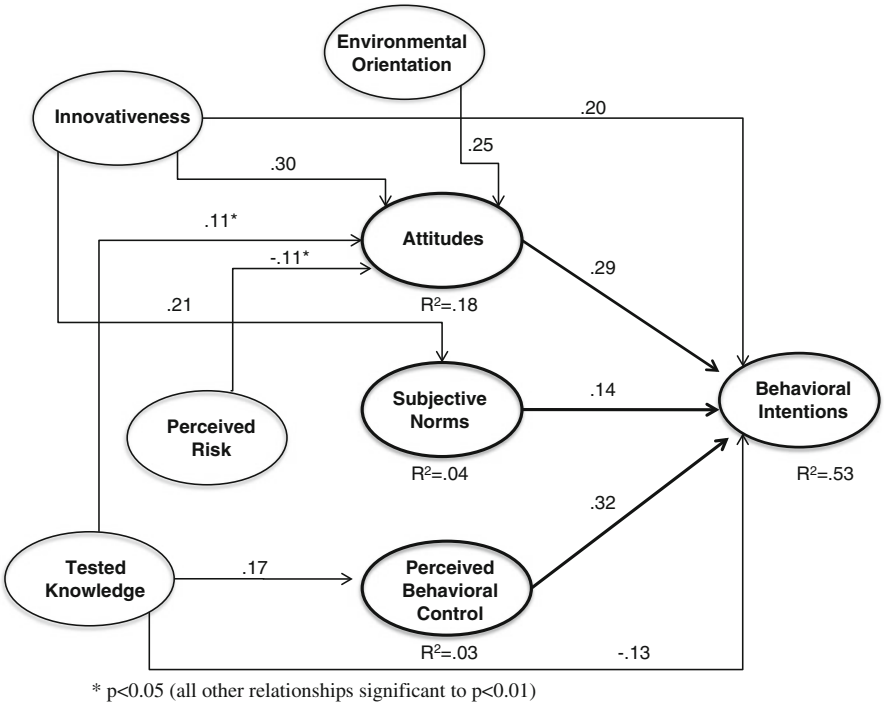

Fig. 3 Final extended Theory of Planned Behavior model (significant relationships)

and intentions (direct effect: $\beta = -.03$; $p = .59$, with perceived behavioral control: $\beta = -.14$; $p = .001$).

Discussion

This research investigated intentions of US NIPF owners to manage forestland for carbon offsets. The Theory of Planned Behavior is applied as a theoretical frame of reference and allows the researcher to identify antecedent constructs (associated with owners) that influence these behavioral intentions. Despite 95 % of the mail survey respondents reporting a lack of current experience with carbon sequestration practices, 50 % were interested in exploring carbon offset opportunities on their forestland. Given the substantial area of forestland owned by non-industrial forestland owners in the US, a significant opportunity for domestic carbon sequestration is evident. However, it should be reiterated that the current sample frame, in accordance with the literature, was limited to those NIPF owners with ten or more acres of forested land and, therefore, findings should not be extended to NIPF owners owning less than ten acres, a group that accounts for 61 % of US NIPF owners but only 8 % of NIPF land.

When applied to behavioral intentions to participate in forest carbon sequestration and trading, the core constructs of the TPB acted as theorized by Ajzen (1991). Attitudes, subjective norms, and perceived behavioral control each positively influenced behavioral intentions ($p < .001$). Perceived behavioral control had the strongest relationship with behavioral intentions, suggesting that forestland owners having the perception of necessary resources (finances and land characteristics) and ability to manage for carbon offsets generally reported higher intentions to do so. Typically, within the TPB, attitude is the strongest predictor of intentions (e.g. Karppinen 2005). Perhaps the overall lack of familiarity with carbon sequestration and trading prompts forestland owners to focus on the practicality of carbon offsets with regard to the availability of necessary resources. Indeed, knowledge regarding carbon sequestration positively influenced both attitude and perceived behavioral control. However, the influence of knowledge was more significant on perceived behavioral control, suggesting that increasing knowledge regarding the practice positively influences the forestland owner's perception of the necessary personal resources and ability to carry out the practice. Carbon sequestration and trading is a relatively uncommon practice in the US; however, as climate change mitigation strategies continue to develop and emission reduction legislation is proposed, familiarity and knowledge regarding the practice will undoubtedly increase within the target population. According to model results, the positive influence of knowledge on attitude and perceived behavioral control may, in turn, positively influence behavioral intentions. However, at time of sampling, more knowledgeable respondents reported lower intentions to sequester carbon on their forestland. This relationship suggests that forestland owners with knowledge of the practice may have also understood that the state of the carbon offset market presented an unattractive investment opportunity at time of publication (see Table 1: Attitude (A) (b_4)).

Subjective norms, although a significant predictor of intentions in this case, had less influence on behavioral intentions than attitude and perceived behavioral control. As noted, forestland owner knowledge influenced the latter two constructs. The current research does not show a similar relationship between knowledge and subjective norms. Given that subjective norms refer to perceived normative pressures rather than personal attitude, personal knowledge of the practice is unlikely to influence the presence of these pressures. Therefore, rather than a direct effect on subjective norms, it is likely that knowledge held by important individuals in the forestland owner's life would be more impactful in the current model. Knowledge of 'important individuals' was not measured in the current research but it can be speculated that, as with knowledge held by forestland owners, knowledge held by important individuals (e.g. foresters) (Wade and Moseley 2011) will develop along with opportunities for carbon sequestration arising through mitigation strategies and legislation.

Innovativeness had a significant positive influence on attitudes and subjective norms, as well as behavioral intentions regarding carbon offsets. The management of forestland for carbon offsets aligns with the classic definition of 'innovation'. Similarly, forestland owners currently managing, or interested in managing, forest carbon offsets can be considered 'early adopters' (or perhaps the 'early majority')

showing a high degree of innovativeness (Rogers and Shoemaker 1971). There was a distinct positive relationship between self-appraised innovativeness and attitudes/intentions related to carbon offset generation, suggesting that those forestland owners with a history of early adoption and/or implementation of new practices are more likely to view the carbon offset 'innovation' as a positive opportunity and plan accordingly. In addition, the positive relationship between innovativeness and subjective norms agrees with previous studies of innovation diffusion (e.g. Mahajan et al. 1990; Rogers 1995). Given that innovative individuals recognize normative influences as valuable sources of new ideas and practices, results from the current study confirm that subjective norms tend to have a stronger positive effect on intentions in more innovative forestland owners. Therefore, as commonly noticed in the adoption of innovations, management of forestland for carbon offsets will be more readily adopted by a segment of early adopters and the early majority as opposed to the late majority and laggards. As suggested by Rogers (1995), the late majority and laggards tend to be 'suspicious' of innovations, as is illustrated by comments made by some forestland owners reporting low innovativeness and minimal interest in managing their forestland for carbon offsets:

> "I do not believe that sequestration will help climate change or make me any money. I don't want the government making decisions about my land."
> *-Tennessee landowner (40 acres)*

Conversely, forestland owners reporting innovative tendencies often provided positive insights regarding carbon offset opportunities:

> "Sequestering carbon promotes better forest management practices and opportunities for added revenue. The environmental benefits are a bonus."
> *-Vermont landowner (50 acres)*

As hypothesized, environmental orientation positively influenced attitudes regarding carbon offset management, suggesting that those forestland owners with a more biocentric value orientation formed more positive attitudes regarding the prospect of managing forestland for carbon offset generation. Given the presence of an emerging post-material (or post-industrial) society in which a biocentric orientation regarding forests and the natural environment is becoming more favored (e.g. Tarrant and Cordell 2002), attitudes regarding pro-environmental practices such as carbon offset generation may become increasingly positive over time. More biocentric individuals tend to be distanced from Pietarinen's (1987) materialism typology (mankind's domination of forests), and are more closely linked to a humanism-mysticism-primitivism continuum (coexistence with forests), therefore, the current findings seem logical in that the influence of environmental orientation on attitude discounts purely monetary or materialistic motivation; a motivation commonly less emphasized by NIPF owners.

As shown in Fig. 3, the extended Theory of Planned Behavior model explains 53 % of the variance in behavioral intentions regarding forest carbon offsetting. β values suggest that extended model constructs (e.g. innovativeness and tested knowledge) had significant direct effects on behavioral intentions, therefore,

illustrating that the addition of these constructs in the extended model increased the amount of variance explained and, thusly, improved the model.

Conclusions

The Theory of Planned Behavior provided a theoretical framework that adequately explained intentions of US private forestland owners to participate in carbon sequestration and trading on their forestland. Results suggest that one's perceived behavioral control was most influential on these intentions, more so than attitudes and subjective norms. It is posited here that the limited knowledge regarding carbon offsets, as reported by respondents, prompts them to place more emphasis on having the necessary resources or ability to manage their land for carbon rather than attitudes towards the behavior which may be dependent upon familiarity. The extended model illustrated this relationship between knowledge, attitude and perceived behavioral control. Similarly, innovativeness tended to positively influence attitudes, subjective norms and intentions related to carbon sequestration, aligning with innovativeness theory. Carbon management can be considered a pro-environmental activity based on the benefits the practice provides to the environment. Accordingly, respondents with a more biocentric environmental orientation tended to hold more positive attitudes about carbon sequestration and trading. Overall, the core components of the TPB, as well as the constructs added in the extended model, explained 53 % of the variance measured within behavioral intentions of private, non-industrial forestland owners to sequester and trade carbon on forestland.

Few forestland owners were currently managing their forestland for sequestered carbon; however, over half were interested in the prospect. The policy and timber supply implications relevant to this research relate to the identification of forestland owner characteristics that influence intentions to participate in an innovative forestry practice. In particular, the effect of knowledge on attitudes suggested that the provision of educational materials for forestland owners through associations, academic institutions, and government agencies may lead to positive attitudes and increasing perceived behavioral control regarding carbon sequestration and trading. Given that knowledge of the practice is quite low, informing these forestland owners will be key if domestic forests are to become a component of a multifaceted climate change mitigation strategy.

Limitations

This research measured intentions of US private forestland owners to participate in carbon sequestration and trading. Given that an exhaustive list of these owners was not available, a mailing list was purchased which included a random selection of owners within defined parameters. List coverage was unequal across US states; therefore, care should be taken when making generalizations to the target population based on findings from this research. Overall, familiarity with the subject matter was

relatively low resulting in frequent 'neutral' responses to questionnaire items. However, sufficient non-neutral responses allowed for statistical analyses. The newness of the subject matter addressed in the questionnaire, coupled with the length of the questionnaire, may have affected response rate.

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